

DECLARATION

I, Susumu Takahashi, residing at 7th Fl., Shuwa Kioicho Park Bldg., 3-6, Kioicho, Chiyoda-ku, Tokyo 102-0094, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the application document of Japanese Patent Application No. 11-165709 filed on June 11, 1999 in the name of MIXED REALITY SYSTEMS LABORATORY INC.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 18th day of October, 2005.

高橋 晋

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Susumu Takahashi

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11-165709

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USER INTERFACE APPARATUS, USER INTERFACE METHOD, GAME  
APPARATUS, AND PROGRAM STORAGE MEDIUM

5

[What Is Claimed Is:]

[Claim 1] A user interface apparatus comprising:

a first sensor attached to a first portion of a  
body of a user;

10 a second sensor attached to a second portion  
different from the first portion;

means for generating action information of the  
second portion on the basis of a relative position of  
the second portion with respect to the first portion,  
15 which is detected by said first and second sensors; and  
determination means for determining a user  
instruction corresponding to the generated action  
information.

[Claim 2] The apparatus according to claim 1,  
20 wherein the first portion is a head.

[Claim 3] The apparatus according to claim 1 or 2,  
wherein the second portion is a hand.

[Claim 4] The apparatus according to any one of  
claims 1 to 3, wherein said first sensor detects a  
25 location/posture of the first portion.

11-165709

[Claim 5] The apparatus according to any one of claims 1 to 4, wherein said second sensor detects a location and posture of the second portion.

[Claim 6] The apparatus according to any one of  
5 claims 1 to 5, wherein the action information includes information which pertains to a state change of the second portion with respect to a location of the first portion, and information which pertains to a location change velocity of the state change.

10 [Claim 7] The apparatus according to any one of claims 1 to 6, wherein the action information includes information which pertains to a state change of the second portion with respect to a location or location/posture of the first portion, and information  
15 which pertains to a location change acceleration of the state change.

[Claim 8] The apparatus according to any one of claims 1 to 7, wherein the action information includes information which pertains to a posture of the second  
20 portion with respect to a posture of the first portion.

[Claim 9] The apparatus according to any one of claims 1 to 8, wherein the action information includes information which pertains to a moving direction of a location of the second portion with respect to a  
25 posture of the first portion.

[Claim 10] The apparatus according to any one of claims 1 to 9, further comprising:

11-165709

means for storing a value of the relative position of the second portion with respect to the first portion, and a plurality of state values which are defined in advance as a result of transition of the value; and

means for storing a plurality of different user instruction values corresponding to the plurality of state values.

[Claim 11] The apparatus according to any one of claims 1 to 10, wherein said determination means decomposes the determined user instruction into a plurality of instruction operands, and outputs the operands.

[Claim 12] The apparatus according to any one of claims 1 to 11, wherein when said generation means determines that a relative relationship between a location/posture of a head detected by said first sensor, and a location/posture of a hand detected by said second sensor indicates an action of the user whose line of sight is pointing to a predetermined portion of the hand,

said determination means outputs a user instruction for outputting an operation guidance.

[Claim 13] The apparatus according to any one of claims 1 to 12, further comprising a third sensor for detecting a bent angle of a finger.

[Claim 14] A game apparatus comprising:

11-165709

a first sensor for detecting a location/posture of a head of a player;

a second sensor for detecting a location/posture of a hand or arm;

5 means for estimating an action of the player on the basis of a relative location/posture of the hand or arm with respect to the location/posture of the head, which are detected by said first and second sensors; and

10 means for outputting a player command corresponding to the estimated action.

[Claim 15] The apparatus according to claim 14, further comprising display means for displaying an image of a game scene in front of the head of the  
15 player for the player.

[Claim 16] The apparatus according to claim 14 or 15, wherein said display means is a head-mounted display.

[Claim 17] The apparatus according to any one of  
20 claims 14 to 16, wherein three steps including preparation, execution, and return steps, are prepared for the player command, and the steps are respectively defined as:

a preparation action step for the player command  
25 when the location of the hand of the player moves to a position behind a position in front of a face of the player;

11-165709

an execution step for the player command when the location of the hand of the player moves forward from a rear position after the preparation action; and

a return action step for the player command when  
5 the location of the hand of the player returns to a position of the face of the player after the forward movement.

[Claim 18] A user interface method for outputting a user instruction to a predetermined apparatus or  
10 program, comprising:

the step of detecting a location of a first portion of a body of a user and a location of a second portion different from the first portion using first and second sensors attached to the user; and

15 the step of determining a user instruction on the basis of a relative position of the second portion with respect to the first portion, which are detected by said first and second sensors, and outputting the determined user instruction to the apparatus or program.

20 [Claim 19] The method according to claim 18, wherein said first and second sensors respectively detect locations/postures of the first and second portions.

[Claim 20] The method according to claim 18 or 19,  
25 wherein the first portion is a head of the user, and the second portion is a hand of the user.

11-165709

[Claim 21] The method according to any one of claims 18 to 20, further comprising the step of detecting information which pertains to a state change of the second portion with respect to a location or a location/posture of the first portion, and information  
5 which pertains to a location change velocity of the state change.

[Claim 22] The method according to any one of claims 18 to 20, further comprising the step of  
10 detecting information which pertains to a state change of the second portion with respect to a location or a location/posture of the first portion, and information which pertains to a location change acceleration of the state change.

15 [Claim 23] The method according to any one of claims 18 to 22, further comprising the step of detecting a posture of the second portion with respect to a posture of the first portion.

[Claim 24] The method according to any one of  
20 claims 18 to 23, further comprising the step of detecting a moving direction of a location of the second portion with respect to a posture of the first portion.

[Claim 25] The method according to any one of  
25 claims 18 to 24, further comprising the step of storing a value of the relative position of the second portion with respect to the first portion, and a plurality of

11-165709

user instructions which are defined in advance as a result of transition of the value.

[Claim 26] The method according to any one of claims 18 to 25, wherein the output step includes the  
5 step of decomposing the determined user instruction into a plurality of instruction operands, and outputting the operands.

[Claim 27] The method according to any one of claims 18 to 26, wherein when it is determined that a  
10 relative relationship between a location/posture of a head detected by said first sensor, and a location/posture of a hand detected by said second sensor indicates an action of the user whose line of sight is pointing to a predetermined portion of the  
15 hand,

the output step includes the step of outputting a user instruction for outputting an operation guidance.

[Claim 28] The method according to any one of claims 19 to 28, further comprising the step of  
20 detecting a bent angle of a finger from a third sensor.

[Claim 29] A computer readable storage medium, which stores a program that makes a computer to perform a user interface method according to any one of claims 18 to 28.

25 [Claim 30] A game apparatus for displaying a CG image in front of a field of view of a player, comprising:

11-165709

a first sensor for detecting a location of a first portion of a body of the player;

a second sensor for detecting a location of a second portion of the player, which is different from  
5 the first portion; and

game progress means for proceeding with a game by determining a command the player wants to input on the basis of a relative position of the second portion with respect to the first portion, which are detected by  
10 said first and second sensors, and executing the determined command.

[Claim 31] The apparatus according to claim 30, wherein said first and second sensors respectively detect locations/postures of the first and second  
15 portions.

[Claim 32] The apparatus according to claim 30 or 31, wherein the first portion is a head of the player, and the second portion is a hand of the player.

[Claim 33] The apparatus according to any one of  
20 claims 30 to 32, further comprising means for detecting information which pertains to a state change of the second portion with respect to the location or a location/posture of the first portion, and information which pertains to a location change velocity of the  
25 state change, and

wherein the command is generated in further consideration of the detected velocity.

11-165709

[Claim 34] The apparatus according to any one of claims 30 to 33, further comprising means for detecting information which pertains to a state change of the second portion with respect to the location or a  
5 location/posture of the first portion, and information which pertains to a location change acceleration of the state change, and

wherein the command is generated in further consideration of the detected acceleration.

10 [Claim 35] The apparatus according to any one of claims 30 to 34, further comprising means for detecting a posture of the second portion with respect to a posture of the first portion, and

wherein the command is generated in further  
15 consideration of the detected posture of the second portion.

[Claim 36] The apparatus according to any one of claims 30 to 35, further comprising means for detecting a moving direction of the location of the second  
20 portion with respect to a posture of the first portion, and wherein the command is generated in further consideration of the detected moving direction of the location of the second portion.

[Claim 37] The apparatus according to any one of  
25 claims 30 to 36, further comprising a memory for storing a value of the relative position of the second portion with respect to the first portion, and a

11-165709

plurality of player commands which are defined in advance as a result of transition of the value.

[Claim 38] The apparatus according to any one of claims 30 to 37, wherein said game progress means  
5 decomposes the determined player command into a plurality of operands, and executes the command in accordance with the plurality of decomposed operands.

[Claim 39] The apparatus according to claim 33, wherein when a relative relationship between a  
10 location/posture of a head detected by said first sensor, and a location/posture of a hand detected by said second sensor indicates that a line of sight of the player is pointing to a predetermined portion of the hand,

15 said game progress means generates a player command for outputting an operation guidance.

[Claim 40] The apparatus according to any one of claims 30 to 39, further comprising a third sensor for detecting a bent angle of a finger.

20 [Claim 41] The apparatus according to any one of claims 1 to 9, wherein the action information further includes geometric information of the first and second portions in a reference coordinate system.

[Claim 42] The apparatus according to any one of  
25 claims 14 to 17, wherein said estimation means extracts geometric information of the first and second portions

11-165709

in a reference coordinate system, and estimates a player action on the basis of the geometric information.

[Claim 43] The method according to any one of claims 18 to 28, wherein the detection step includes  
5 the step of extracting geometric information of the first and second portions in a reference coordinate system.

[Claim 44] The apparatus according to any one of claims 30 to 40, wherein said game progress means  
10 further extracts geometric information of the first and second portions in a reference coordinate system, estimates an action of the player on the basis of the geometric information, and determines the command the player wants to input on the basis of the estimated  
15 action.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Belongs]

The present invention relates to a user interface  
20 apparatus and method, and a game apparatus, which generate an instruction (or command) by adequately detecting player's (user's) actions in, e.g., an action game.

[0002]

25 [Prior Art]

A current personal computer system uses as a user interface a pointing device such as a mouse, track pad,

11-165709

or the like. However, the user must hold the mouse and slide it on a given surface. On the other hand, the user must rub against the surface of the track pad with his or her hand. Thus, these pointing devices limit  
5 user's actions. A GUI (Graphical User Interface) used in the personal computer system or the like is that for a two-dimensional space, and is not suitable for that in a three-dimensional space.

[0003]

10 For these reasons, it is a common practice in the technical field of VR (Virtual Reality) or AR (Augmented Reality) to input commands to the system by switch operations of an input device which is held by a user's (player's) hand and has switch buttons, and the  
15 like.

[0004]

[Problems That the Invention Is to Solve]

In the prior art in which commands are input by switch operations on the input device having button  
20 switches and the like, the number of types or number of commands (instructions) is limited by the number of buttons. If the number of types or number of commands (or instructions) is increased, the number of buttons increases inevitably. As a result, the input device  
25 becomes large in size, and the load on the user (player) becomes heavier as he or she must learn the button positions.

11-165709

[0005]

Learning the button positions imposes a heavy load on the user since the command contents do not match the button positions. To put it differently, expressing various command contents (e.g., "forward movement", "backward movement", "stop", and the like) by one operation, i.e., depression of a button (or a switch) is difficult if not impossible.

[0006]

On the other hand, in the VR (Virtual Reality) or AR (Augmented Reality) field, a device for simulating user's (player's) hand actions has been proposed. For example, in one technique, a sensor for detecting the bent angle of a joint of a finger is attached to a hand of the user, and a CG (computer graphic) image is generated in correspondence with the bent angle of the finger detected by that sensor. However, this technique aims at simulating hand actions of the user, and it is impossible to apply this technique to that for recognizing the user (player) instructions (or commands) in practice.

[0007]

In this technique, for example, when the user stretches the arm forward, a CG image with the arm stretched forward is generated, and display of such image can be interpreted to be a result of a user instruction or forward stretching of the arm in the

11-165709

broad sense. However, if user commands are generated by only hand actions, every hand actions are unwantedly interpreted as commands, and such interface has poor reliability.

5 [0008]

The present invention has been made to solve the conventional problems and has as its object to provide a user interface apparatus, user interface method, and game apparatus, to which the user (player) can easily  
10 sensuously become accustomed, and which can accurately recognize instructions (commands) that the user (player) intended.

[0009]

[Means of Solving the Problems]

15 In order to achieve the above object, a user interface apparatus according to claim 1 comprises:

[0010]

a first sensor attached to a first portion of a body of a user;

20 a second sensor attached to a second portion different from the first portion;

[0011]

means for generating action information of the second portion on the basis of a relative position of  
25 the second portion with respect to the first portion, which is detected by the first and second sensors; and

[0012]

11-165709

determination means for determining a user instruction corresponding to the generated action information.

[0013]

5 Also, a game apparatus according to claim 14 comprises:

[0014]

a first sensor for detecting a location/posture of a head of a player;

10 [0015]

a second sensor for detecting a location/posture of a hand or arm;

[0016]

means for estimating an action of the player on  
15 the basis of a relative location/posture of the hand or arm with respect to the location/posture of the head, which are detected by the first and second sensors; and  
[0017]

means for outputting a player command  
20 corresponding to the estimated action.  
[0018]

Likewise, a user interface method for outputting a user instruction to a predetermined apparatus or program according to claim 18 comprises:  
25 [0019]

the step of detecting a location of a first portion of a body of a user and a location of a second

11-165709

portion different from the first portion using first  
and second sensors attached to the user; and

[0020]

the step of determining a user instruction on the  
5 basis of a relative position of the second portion with  
respect to the first portion, which are detected by the  
first and second sensors, and outputting the determined  
user instruction to the apparatus or program.

[0021]

10 In claims 1, 14 and 18, when the user (player)  
expresses his or her intention or instruction by his or  
her own action, he or she often expresses it by a  
combination of actions of a plurality of his or her  
body portions. Such combination of actions can be  
15 estimated by detecting the location of the second  
portion relative to the first portion, as described  
above.

[0022]

The user or player normally expresses an action  
20 by a relative location with respect to his or her  
field-of-view direction. The field-of-view direction  
is roughly determined by the head location. Hence,  
according to claim 2, which is a preferred aspect of  
the present invention, the first portion is a head.

25 [0023]

According to claim 3, which is a preferred aspect  
of the present invention, the second portion is a hand.

11-165709

This is because it is easiest for the user to express an action by hand.

[0024]

According to any one of claim 4, 5, 19 and 20,  
5 which is a preferred aspect of the present invention, the first (second) sensor detects a location or location/posture of the first (second portion.

[0025]

User's (player's) action is preferably recognized  
10 as a state change. Hence, according to claim 6 or 21, which is a preferred aspect of the present invention, information which pertains to a state change of the second portion with respect to a location of the first portion, and information which pertains to a location  
15 change velocity of the state change are detected.

[0026]

According to claim 7 or 22, which is a preferred aspect of the present invention, information which pertains to a state change of the second portion with  
20 respect to a location of the first portion, and information which pertains to a location change acceleration of the state change are detected.

[0027]

According to claim 8 or 23, which is a preferred  
25 aspect of the present invention, information which pertains to a posture of the second portion with respect to a posture of the first portion is detected.

11-165709

[0028]

According to claim 9 or 24, which is a preferred aspect of the present invention, information which pertains to a moving direction of a location of the  
5 second portion with respect to a posture of the first portion is detected.

[0029]

Various methods of analyzing an action state are available. According to claim 10 or 25 as a preferred  
10 aspect of the present invention, a value of the relative position of the second portion with respect to the first portion, a plurality of state values which are defined in advance as a result of transition of the value, and a plurality of different user instruction  
15 values corresponding to the plurality of state values are stored.

[0030]

A user instruction or command is composed of a plurality of portions in practice, and it is  
20 advantageous for a program to individually execute those portions of the instruction or command. Hence, according to claim 12 or 26, which is a preferred aspect of the present invention, the determined user instruction or command is decomposed into a plurality  
25 of instruction operands, and the operands are output.

[0031]

11-165709

According to claim 12 or 27, which is a preferred aspect of the present invention, when it is determined that a relative relationship between a location/posture of a head detected by the first sensor, and a  
5 location/posture of a hand detected by the second sensor indicates an action of the user whose line of sight is pointing to a predetermined portion of the hand, a user instruction for outputting an operation guidance (so-called on-line HELP) is generated.  
10 [0032]

According to claim 13 or 28, which is a preferred aspect of the present invention, a third sensor for detecting a bent angle of a finger is further used.  
[0033]

15 When the present invention is applied to the game apparatus, a display device is preferably used. Hence, the game apparatus according to claim 15 as a preferred aspect of the present invention comprises display means for displaying an image of a game scene in front of the  
20 head of the player for the player. Furthermore, according to claim 17, the display means is preferably a head-mounted display.  
[0034]

When the present invention is applied to the game  
25 apparatus, three steps including preparation, execution, and return steps, are preferably prepared for the player command. According to claim 17, which is a

11-163709

preferred aspect of the present invention, the steps are respectively defined as:

[0035]

a preparation action step for the first player  
5 command when the location of the hand of the player moves to a position behind a position in front of a face of the player;

[0036]

an execution step for the first player command  
10 when the location of the hand moves forward from a rear position after the preparation action; and

[0037]

a return action step for the first player command when the location of the hand returns to a position of  
15 the face of the player after the forward movement.

[0038]

Note that the above object can also be achieved by a program storage medium that stores a computer program for implementing the aforementioned user  
20 interface method, as defined in claim 29.

[0039]

[Embodiments]

A game apparatus to which a user interface of the present invention is applied will be described in  
25 detail hereinafter with reference to the accompanying drawings. As will be apparent from the following description of the embodiment, the user interface of

11-165709

the present invention can be applied to a personal computer system or workstation system for providing a VR or AR environment to the user in addition to the game apparatus by modifying the present invention  
5 within the scope of the invention.

[0040]

Fig. 1 shows a user 1000 who manipulates the game apparatus of this embodiment. A magnetic sensor 100 as an example of a location/posture detection means is  
10 attached to the head of the user 1000, and a magnetic sensor 200 is also attached to a hand. The magnetic sensors output electrical signals including information of a three-dimensional location (x, y, z) and posture (roll, pitch, yaw) of the portions where they are  
15 attached.

[0041]

Fig. 2 shows the game apparatus system of this embodiment. Referring to Fig. 2, the game system of this embodiment has a command generation unit 2000 for  
20 receiving signals from the two sensors and converting them into a command, and a game apparatus 3000. The command generation unit 2000 analyzes an action of the user 1000 on the basis of the output signals from the sensors 100 and 200, and generates a command in  
25 accordance with the analysis result. The generated command is sent to the game apparatus 3000, which executes the command, i.e., the game progresses.

11-165709

[0042]

The arrangement and operation of the command generation unit 2000 will be described below. As shown in Fig. 2, the unit 2000 has location/posture measurement sections 2001a and 2001b, action analysis section 2002, and command conversion section 2003.

[0043]

The location/posture measurement sections 2001a and 2001b convert electrical signals input from the location sensors 100 and 200 into six each coordinate values representing the locations/postures of the individual portions, and send them to the action analysis section 2002. The location/posture measurement sections 2001a and 2001b have internal clocks to measure a measurement time  $t$  in addition to the six each coordinate values of the locations/postures, and output the measured times to the command generation unit 2000.

[0044]

The action analysis section 2002 analyzes an action in consideration of not only the absolute locations/postures of the head and hand but also their relative location/posture. This is for the following reason. That is, a person normally expresses his or her own intention by actions of a plurality of body portions. In other words, when the location/posture of only one portion are detected and the user's intention

11-165709

is estimated based on them, many errors are produced even when the detected location/posture have high precision. For example, as for a forward stretching action of the arm, a forward stretching action of the  
5 arm with the head facing forward has a meaning different from that with the head facing another direction. For example, if the action "to stretch the arm forward" means "attack", since attack is normally done with the player's head facing the target (i.e., in  
10 the stretching direction of the arm), the player may intend an action other than attack if he or she stretched the arm with the head facing another direction. Hence, if no posture is taken into consideration, a forward stretching action of the arm  
15 with the head facing another direction is highly likely to be erroneously recognized as attack. For this reason, in this embodiment, the estimation precision of the user's intention is improved by taking relative location/posture (e.g., the location/posture of the  
20 hand relative to those of the head) into consideration.  
[0045]

Fig. 3 shows the relationship between the locations/postures of the head and hand in a reference coordinate system, and Fig. 4 shows the relationship  
25 between the locations/postures of the head and hand in a head coordinate system. Figs. 5 and 6 respectively show the head and hand coordinate systems.

11-165709

[0046]

Fig. 7 shows the functions of the action analysis section 2002. The functions shown in Fig. 7 are implemented by the control sequence according to the flow chart shown in Fig. 8. According to the flow chart shown in Fig. 8, three-dimensional locations ( $L_{head}$  and  $L_{hand}$ ) and postures  $P$  ( $P_{head}$  and  $P_{hand}$ ) of the head and hand are input from the location/posture measurement sections 2001 in step S2, and a location and posture ( $L'_{hand}$  and  $P'_{hand}$ ) of the hand relative to the head are computed based on the input locations and postures in step S4. More specifically, a coordinate transform matrix  $M_{hand}$  from the reference coordinate system into the hand coordinate system is computed on the basis of the hand location and posture ( $L_{hand}$  and  $P_{hand}$ ), a coordinate transform matrix  $M_{head}$  from the reference coordinate system into the head coordinate system is computed on the basis of the location and posture ( $L_{head}$  and  $P_{head}$ ) of the head, and based on these matrices, a coordinate transform matrix  $M'_{hand}$  from the head coordinate system into the hand coordinate system is computed with the following [Equation 1]:

[0047]

[Equation 1]

$$M'_{hand} = M_{hand} \cdot M_{head}^{-1}$$

[0048]

11-165709

where  $M_{\text{head}}^{-1}$  is the inverse matrix of  $M_{\text{head}}$ . The relative location and posture ( $L'_{\text{hand}}$ ,  $P'_{\text{hand}}$ ) of the hand with reference to the head (i.e., in the head coordinate system) can be easily derived from  $M'_{\text{hand}}$ .

5        In step S6, change velocity  $V_{\text{hand}}$  (time derivative of  $L'_{\text{hand}}$ ) of the hand location  $L'_{\text{hand}}$ , and acceleration  $A_{\text{hand}}$  (time derivative of velocity  $V_{\text{hand}}$ ) are computed. Note that the currently measured location and posture ( $L'_{\text{hand}}$ ,  $P'_{\text{hand}}$ ) of the hand relative to the head are  
10        stored in a predetermined memory for the next velocity and acceleration computations in step S6. In this case, data for two previous measurements suffice. In this specification, a combination of information of the location, posture, time, and the like for the head, and  
15        those for the hand input from the location/posture measurement sections 2001 is called "primary information", and the location and posture, and velocity and acceleration of the hand with reference to the head are called "secondary information".

20        [0049]

         It is checked in step S8 if "secondary information" satisfies a predetermined state transition condition so as to determine transition of state  $\phi$ . The operation of the action analysis section 2002 upon  
25        applying the functions shown in Figs. 7 and 8 to an action (shooting) game will be explained below. In this shooting game, the following five states are

11-165709

defined, and values 0 to 4 are assigned in advance to these states.

- 0 = initial state
- 1 = loading (load a gun) state
- 5 2 = shooting state
- 3 = defense (protect a player) state
- 4 = operation guidance state

[0050]

In this game apparatus, an action is expressed by a  
10 change in state value. As shown in Fig. 9, actions defined in this game apparatus are as follows:

<u>Transition</u>	<u>Action</u>
* → *	No action (no change in state value)
15 0 → 1	Loading action
1 → 0	Loading cancel action
1 → 2	Firing action
0 → 3	Defense action
3 → 0	Defense cancel action
20 0 → 4	Operation guidance action
4 → 0	Operation guidance cancel action

Note that the initial state is restored a predetermined period of time elapsed after the firing state. The output from the action analysis section 2002 includes  
25 action state  $\phi$  and three-dimensional information of the head and hand.

11-165709

Fig. 10 is a flow chart showing the overall state transition condition determination process of the action analysis section 2002. More specifically, the action analysis section 2002 executes one of steps S100, S200, S300, S400, and S500 (respectively shown in detail in Figs. 11, 12, 13, 14, and 15) in accordance with the current state value  $\phi$ . Each of steps S100, S200, S300, S400, and S500 outputs the action state value  $\phi$  after transition, and three-dimensional information of the head and hand.

[0051]

The control sequence when the current state value = 0, i.e., "initial state" is currently set, will be explained below with reference to Fig. 11. There are four states to which the initial state can transit, i.e., state 0 (no transition), state 1 (loading state), state 3 (defense state), and state 4 (operation guidance state), in the game apparatus of this embodiment. In the control sequence shown in Fig. 11, to which of the four states the initial state is to transit is determined in consideration of the amount of backward movement of the hand with respect to the head in the back (z) direction, the deviation of the angle the back-and-forth direction (z-direction in Fig. 6) of the hand makes with the back direction (z-direction in Fig. 5) of the player's head, the deviation of the angle the back of the hand (y-direction in Fig. 6)

11-165709

makes with the back direction of the head, and the like.  
Hence, the following variables  $z_{hand}$ ,  $\alpha_1$ , and  $\alpha_2$  must be  
considered in the control sequence shown in Fig. 11.

[0052]

5            $z_{hand}$ : z-coordinate value of hand location with  
reference to head coordinate system (see Fig. 5)

[0053]

$\alpha_1$ : angle z-axis of head coordinate system makes  
with that of hand coordinate system (see Fig. 6)

10 [0054]

$\alpha_2$ : angle z-axis of head coordinate system makes  
with y-axis of hand coordinate system

[0055]

          Assume that constant values  $C_{01}$ ,  $C_{02}$ ,  $C_{03}$ , and  $C_{04}$   
15 are respectively:

$C_{01} = 0.0$  (length)

[0056]

$C_{02} = 45^\circ$

[0057]

20            $C_{03} = 150^\circ$

[0058]

$C_{04} = 30^\circ$

[0059]

          Then, if YES in steps S102 and S104, i.e., in  
25 case that

$z_{hand} > C_{01}$  and  $\alpha_1 < C_{02}$ .

11-165709

in other words, if the player has moved the hand backward to a location behind the center of the head ( $C_{01} = 0.0$ ) in the back direction of the head while the deviation of the angle the direction of the hand makes with the back direction of the head is kept suppressed to be equal to or smaller than  $45^\circ$ , it is determined that the player wants to make a loading action. Then, the current time  $t$  is saved in a register  $t_{01}$  in step S106, the current hand location  $L_{hand}$  is saved in a register  $L_{01}$  in step S108, and an action state value = 1 (loading state) is output in step S110.

[0060]

On the other hand, if NO in steps S102 and S104, and YES in step S112, i.e., in case that

[0061]

$Z_{hand} \leq C_{01}$  and  $\alpha_1 \geq C_{02}$  and  $\alpha_2 > C_{03}$ ,

in other words, if the player has moved the hand to a location in front of the central position of the head while the deviation of the angle the direction of the hand makes with the back direction of the head is  $45^\circ$  or more, and an angle the direction perpendicular to the back of the hand makes with the back direction of the head is  $150^\circ$  or more, it is determined that the player wants to make a defense action. Then, the current time  $t$  is saved in a register  $t_{03}$  in step S114, and an action state value = 3 (defense state) is output in step S116.

11-165709

[0062]

On the other hand, if NO in steps S102, S104, and S112, and YES in step S118, i.e., in case that

[0063]

5  $z_{\text{hand}} \leq C_{01}$  and  $\alpha_1 \geq C_{02}$  and  $\alpha_2 < C_{04}$ ,

in other words, if the player has moved the hand to a location in front of the central position of the head while the deviation of the angle the direction of the hand makes with the back direction of the head is  $45^\circ$  or more, and an angle the direction perpendicular to the back of the hand makes with the back direction of the head is  $30^\circ$  or less, it is determined that the player wants an operation guidance (i.e., HELP). Then, the current time  $t$  is saved in a register  $t_{04}$  in step 10 S120, and an action state value = 4 (operation guidance state) is output in step S122.

[0064]

On the other hand, if NO in all steps S102, S104, S112, and S118, i.e., in case that

20 [0065]

$z_{\text{hand}} \leq C_{01}$  and  $\alpha_1 \geq C_{02}$  and  $C_{04} \leq \alpha_2 \leq C_{03}$ ,

it is determined that the player's action is not large enough to issue a command, and the initial state is maintained in step S124.

25 [0066]

The control sequence when the current state is the loading state (= 1) will be explained below with

11-165709

reference to Fig. 12. There are three states to which the loading state can transit, i.e., state 0 (initial state), state 1 (no transition), and state 2 (firing state), as shown in Fig. 9. In the control sequence  
5 shown in Fig. 12, a hand moving distance  $d$ , hand angle  $\alpha_3$ , and hand moving velocity  $v$  are referred to in addition to the aforementioned angle  $\alpha_1$ . Note that  
[0067]

$d$ : distance from hand location  $L_0$  to current hand  
10 location  $L_{\text{hand}}$  when state transits from 0 to 1  
[0068]

$\alpha_3$ : angle a velocity vector  $V$  of hand makes with  
z-axis of head coordinate system  
[0069]

15  $v$ : moving velocity of hand  
[0070]

Assume that constant values  $C_{11}$ ,  $C_{12}$ ,  $C_{13}$ , and  $C_{14}$   
are respectively:

$C_{11} = 60^\circ$  (to be compared with  $\alpha_1$ )  
20 [0071]

$C_{12} = 300 \text{ mm}$  (to be compared with  $d$ )  
[0072]

$C_{13} = 120^\circ$  (to be compared with  $\alpha_3$ )  
[0073]

25  $C_{14} = 300 \text{ mm/s}$  (to be compared with  $v$ )  
[0074]

Then, if

11-165709

$$\alpha_1 > C_{11}$$

in step S201, in other words, the deviation of the angle the hand direction makes with the back direction of the head has exceeded  $60^\circ$ , it is determined that the  
5 player has made a loading action but does not want to fire. Then, the current time  $t$  is saved in a register  $t_{10}$  in step S202, and an action state value = 0 is output in step S204.

[0075]

10 On the other hand, if NO in step S201 and YES in steps S206, S208, and S210, i.e., in case that

[0076]

$$\alpha_1 \leq C_{11}, d > C_{12}, \alpha_3 > C_{13}, v > C_{14},$$

in other words, if a change in direction of the hand  
15 with respect to the head is not large, the hand moving distance is equal to or larger than  $C_{12}$  (e.g., 300 mm), the angle the hand moving direction makes with the back direction of the head is equal to or larger than the angle  $C_{13}$  (e.g.,  $120^\circ$ ), and the hand moving velocity is  
20 equal to or higher than  $C_{14}$  (e.g., 300 mm/s), it is determined that the player wants to fire. Then, the current time  $t$  is saved in a register  $t_{12}$  in step S212, and an action state value = 2 (firing state) is output in step S214.

25 [0077]

On the other hand, if the above conditions are not satisfied, i.e., in case that

11-165709

[0078]

 $\alpha_1 \leq C_{11}$  and  $d \leq C_{12}$  or  $\alpha_3 \leq C_{13}$ ,  $v \leq C_{14}$ ,

the loading state is maintained.

[0079]

5        When the current state is the firing state (= 2),  
the control sequence shown in Fig. 13 is executed. In  
the example shown in Fig. 9, the firing state can  
transit to either the initial state or firing state (no  
transition). According to the control sequence shown  
10 in Fig. 13, if time  $\Delta t$  elapsed after the loading state  
transits to the firing state is smaller than a constant  
value  $T_2$  (e.g., 200 ms) (NO in step S302), the firing  
state is maintained in step S308. On the other hand,  
if time  $\Delta t$  is equal to or longer than  $T_2$ , the current  
15 time is saved in step S304, and the state is returned  
to the initial state to output that state value in step  
S306.

[0080]

20        In the example in Fig. 9, the initial state is  
unconditionally restored the predetermined period of  
time ( $T_2$ ) after the beginning of shooting. Such simple  
state transition to the initial state is designed for  
the sake of simplicity upon explaining the rules of the  
game of the game apparatus of this embodiment. If the  
25 game has a complex flow (scenario), more states should  
be defined in correspondence with that complexity. In  
such case, more states in addition to the initial state

11-165709

may be defined as those to which the firing state can transit.

[0081]

When the current state is the defense state (= 3),  
5 the control sequence shown in Fig. 14 is executed. In  
the example shown in Fig. 9, states to which the  
defense state can transit are only the initial state  
and the defense state (no transition). According to  
the control sequence shown in Fig. 14, it is checked in  
10 step S402 if an angle the posture of the hand makes  
with that of the head is smaller than a predetermined  
value  $C_{31}$  (e.g.,  $150^\circ$ ). That is, if

[0082]

$$\alpha_2 < C_{31}.$$

15 in other words, if an angle the direction of the back  
of the hand makes with the back direction of the head  
is set to be less than  $150^\circ$ , it is determined that the  
defense state is canceled, and the current state is  
returned to the initial state and the current time is  
20 saved in step S404. Furthermore, the initial state (= 0) is output in step S406.

[0083]

On the other hand, if NO in step S402, but if it  
is determined in step S407 that time  $\Delta t$  elapsed after  
25 the previous state transited to the defense state is  
equal to or longer than a predetermined time  $T_3$ , the  
flow advances to step S404 to return the current state

11-165709

to the initial state like in the case wherein a sufficiently long time has elapsed from the firing state.

[0084]

- 5           Furthermore, if NO in steps S402 and S407, i.e., in case that

[0085]

$$\alpha_2 \geq C_{31} \text{ and } \Delta T \leq T_1,$$

the defense state is maintained.

- 10 [0086]

If the state transits to "operation guidance state" in step S122 in Fig. 11, i.e., in case that

[0087]

$$z_{\text{hand}} \leq C_{01} \text{ and } \alpha_1 \geq C_{02} \text{ and } \alpha_2 \leq C_{04}.$$

- 15 in other words, if the player moves the hand to a location in front of the central position of the head in the back direction of the head while the deviation of the angle the direction of the hand makes with the back direction of the head is 45° or more, and an angle  
20 the direction perpendicular to the back of the hand makes with the back direction of the head is 30° or less, this means that the player is watching the back or joint of the hand. In such case, since a state value = 4 is output to the game apparatus 3000, the  
25 apparatus 3000 displays a HELP window on the predetermined display device. Note that this display device is preferably a head-mounted display device

11-165709

(HMD). If the HMD is used, the player need not move the head upon watching the HELP window, and the control sequence (Fig. 15) for maintaining the "operation guidance state" need not be complicated.

5 [0088]

Note that the HELP window may be either two- or three-dimensional display, or may be displayed in either a VR or AR environment, as long as it matches the current environment. In this embodiment, since the  
10 head location/posture sensor is attached to the player, it is preferable to display the HELP window in an AR environment in terms of efficient use of the sensor 100.

Various modifications of the present invention can be made.

15 [0089]

Modification 1:

[0090]

In the above embodiment, commands and states shown in Fig. 9 are used. However, the present  
20 invention is not limited to such specific commands and states. That is, the user interface of the present invention is not limited to a game apparatus environment. The present invention can be applied to any other environments as long as the user's or  
25 player's actions are required to be used in place of commands (or instructions) upon presenting CG data to the user or player.

11-165709

[0091]

For example, the present invention may be applied to a sign language recognition user interface, a user interface for manipulating home electronic products, a user interface for manipulating industrial machines (special vehicles for construction work, factory lines), a user interface for physically handicapped person assist apparatuses (assist bed, motored wheelchair), and the like.

10 [0092]

Modification 2:

[0093]

When the present invention is applied to a game apparatus, the game to which the present invention is applied is not limited to the rules shown in Fig. 9. The present invention can be applied to more or less states (commands). Also, state transition is not limited to Fig. 9.

[0094]

20 Modification 3:

[0095]

In the game system of the above embodiment, since the action states have one-to-one correspondence with commands or instructions, the command conversion section 2003 can directly convert an action state into a command. However, the present invention is not limited to such specific system. That is, the command

11-165709

conversion unit 2003 is designed to improve compatibility to the game apparatus 3000 connected to the unit 2000. In other words, the game apparatus 3000 can be an existing versatile game apparatus. The  
5 existing game apparatus has an existing command system. The command conversion section 2003 is designed to have a table for receiving outputs (state, velocity, acceleration) from the action analysis section 2002, and converting them into a command system for the game  
10 apparatus 3000. This table is rewritable, and the table contents are rewritten in correspondence with the game apparatus 3000 used. In this way, the unit 2000 can be applied to a plurality of different types of game apparatuses having different command systems  
15 without changing the arrangement and operation of the unit 2000.

[0096]

## Modification 4:

[0097]

20 In the above embodiment, sensors are attached to the head and hand. However, the present invention is not limited to this. That is, to achieve the objective for issuing a command by an action, the sensor may be attached to the fingertip, arm, leg, thigh, knee, or  
25 shin in place of the hand. For example, as an example of a sensor to be attached to finger joints, a so-

11-165709

called "glove type hand joint angle measurement device" has been put into practice.

[0098]

Modification 5:

5 [0099]

In the above embodiment, the command conversion section 2003 receives an action identifier from the analysis section 2002, and outputs a command signal corresponding to an action. Upon receiving this  
10 command, the command signal system of the programs and apparatuses (game apparatus and the like) that use the command signal is defined in the game apparatus 3000. However, the present invention is not limited to such specific command signal. As the command signal, the  
15 following formats are available. That is,

[0100]

to output a command signal as an electrical or optical signal;

[0101]

20 to implement command conversion as a function program on a computer, and output data to be written in a predetermined storage area by the function program to the conversion unit 2003 as a command signal;

[0102]

25 to implement command conversion as a function program on a computer, and launch a callback function

11-165709

which corresponds to a command in advance to use it as  
a command signal output; and

[0103]

to implement command conversion as a function  
5 program on a computer, and generate an interrupt signal  
which corresponds to a command in advance to use it as  
a command signal output.

[0104]

Modification 6:

10 [0105]

In the above embodiment, magnetic sensors are  
used as the sensors. Alternatively, the  
location/posture may be measured using an ultrasonic  
wave, mechanically, or by means of an image process.

15 [0106]

[Effects of the Invention]

As described, according to the present invention,  
a user interface apparatus, user interface method, and  
game apparatus, to which the user (player) can easily  
20 sensuously become accustomed, and which can accurately  
recognize instructions (commands) that the user  
(player) intended can be provided.

[Brief Description of the Drawings]

[Fig. 1]

25 A view for explaining the layout of sensors  
attached to a player who joins in a game system  
according to an embodiment of the present invention.

11-165709

[Fig. 2]

A block diagram for explaining the arrangement of the game system according to the embodiment of the present invention.

5 [Fig. 3]

A view for explaining the relationship between the head and hand coordinate systems when viewed from a reference coordinate system as the center.

[Fig. 4]

10 A view for explaining the relationship between the head and hand coordinate system when viewed from the head coordinate system as the center.

[Fig. 5]

15 A view for explaining setups of a coordinate system of a head sensor 100 according to the scheme shown in Fig. 4.

[Fig. 6]

20 A view for explaining setups of a coordinate system of a hand sensor 200 according to the scheme shown in Fig. 4.

[Fig. 7]

A block diagram for functionally explaining the arrangement of a command generation unit 2000.

[Fig. 8]

25 A flow chart for explaining the overall sequence of an action analysis section 2002.

[Fig. 9]

11-165709

A view for explaining state transition in the game system according to the embodiment of the present invention.

[Fig. 10]

5           A flow chart for explaining details of step S8 in Fig. 8.

[Fig. 11]

A flow chart for explaining details of step S100 in Fig. 10.

10   [Fig. 12]

A flow chart for explaining details of step S200 in Fig. 10.

[Fig. 13]

A flow chart for explaining details of step S300 in Fig. 10.

[Fig. 14]

A flow chart for explaining details of step S400 in Fig. 10.

[Fig. 15]

20           A flow chart for explaining details of step S500 in Fig. 10.

11-165709

[Type of the Document] Abstract

[Abstract]

[Problem] To provide a user interface apparatus to which the user (player) can easily sensuously become  
5 accustomed, and which can accurately recognize instructions (commands) that the user (player) intended.

[Solving Means] The user interface apparatus has a location/posture sensor (100) attached to the head of the user, and a location/posture sensor (200) attached  
10 to his or her hand, analyzes hand action on the basis of the relative position of the location/posture of the hand with respect to those of the head, and estimates the current action state from the analysis result. The apparatus then determines a user instruction (player  
15 command) on the basis of the action state.

[Selected Drawings] Fig. 7

(TYPE OF THE DOCUMENT) DRAWINGS

FIG. 1

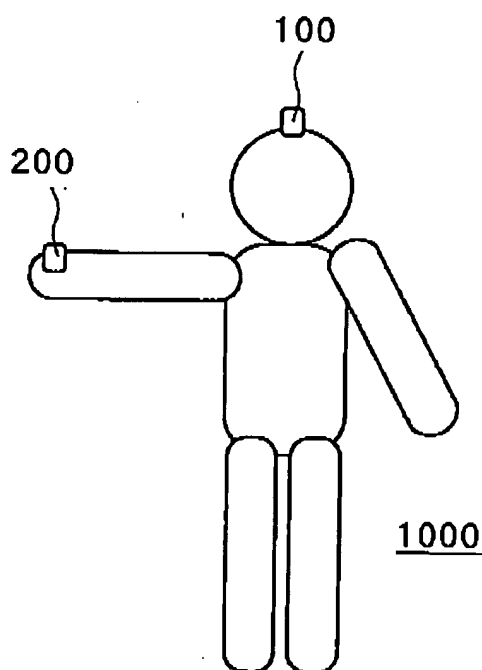
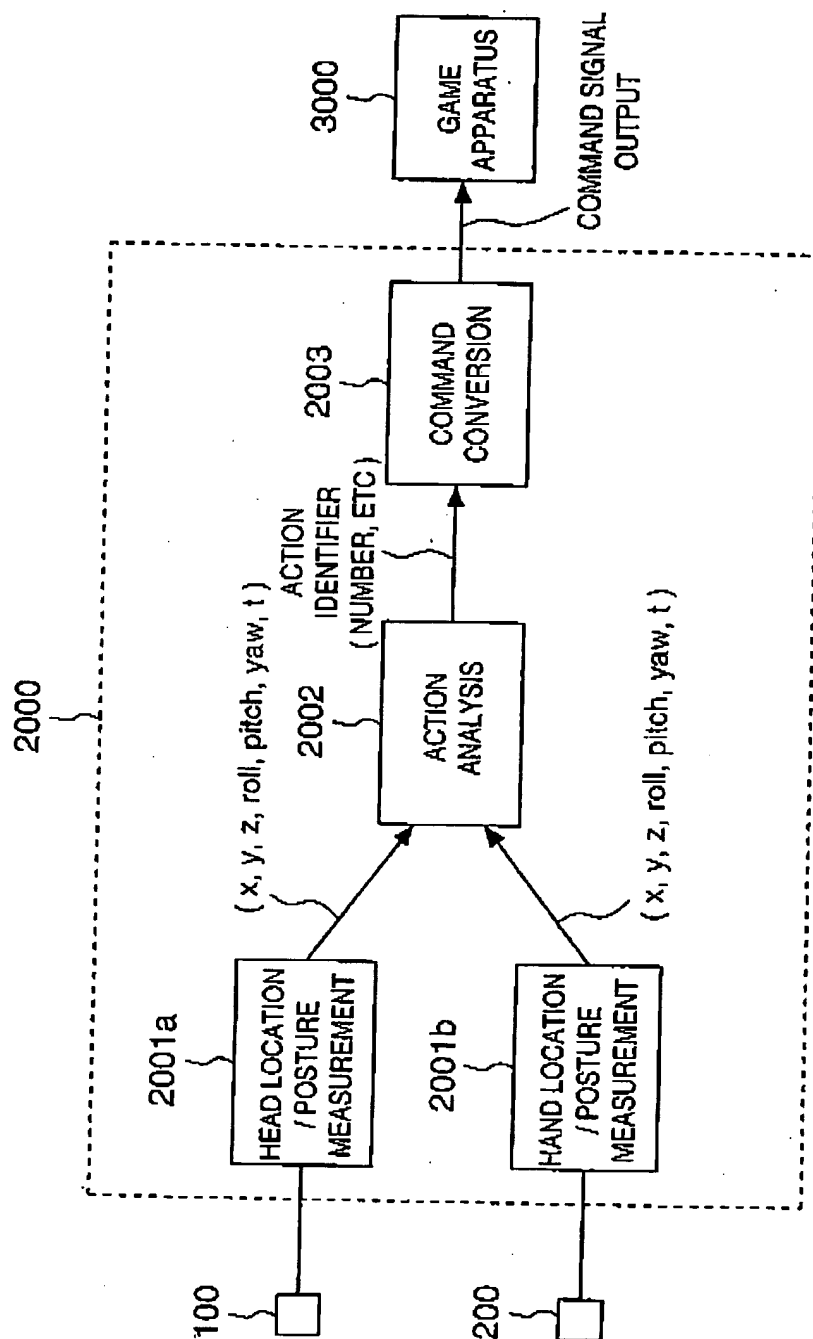
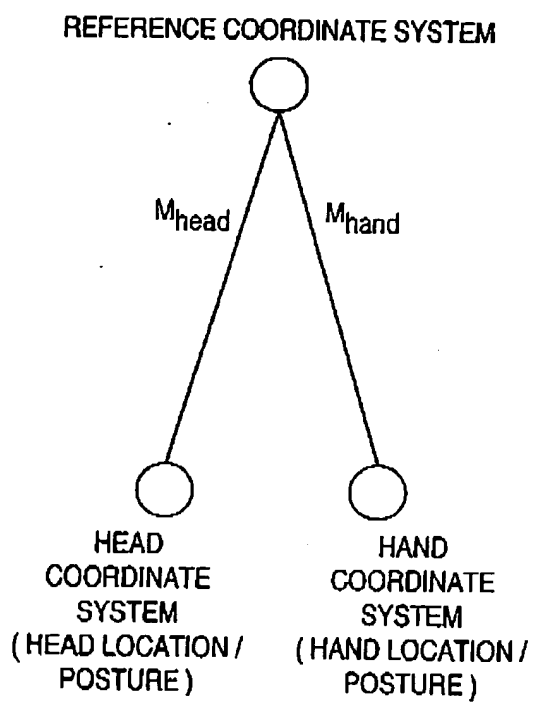


FIG. 2



**FIG. 3**

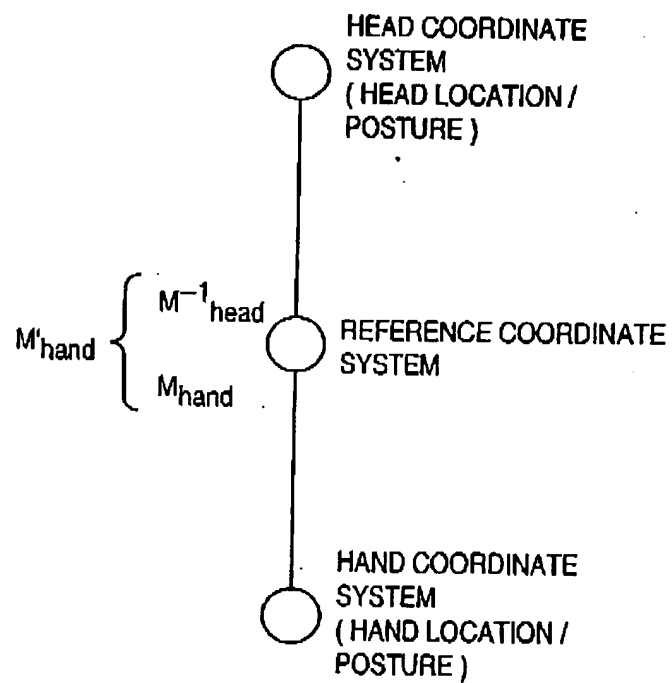
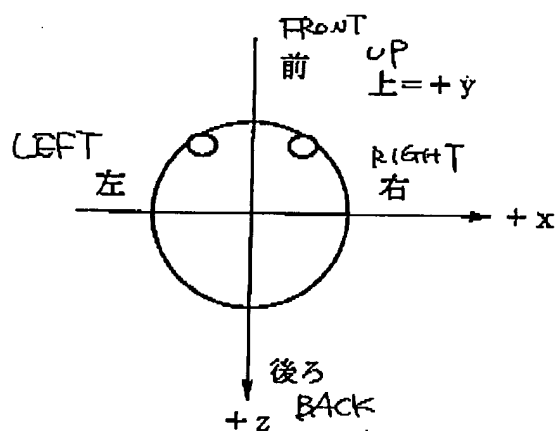
**FIG. 4**

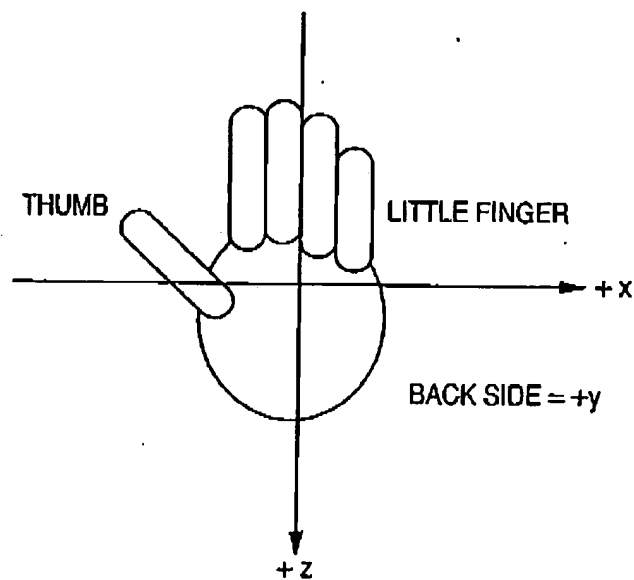
Fig. 5

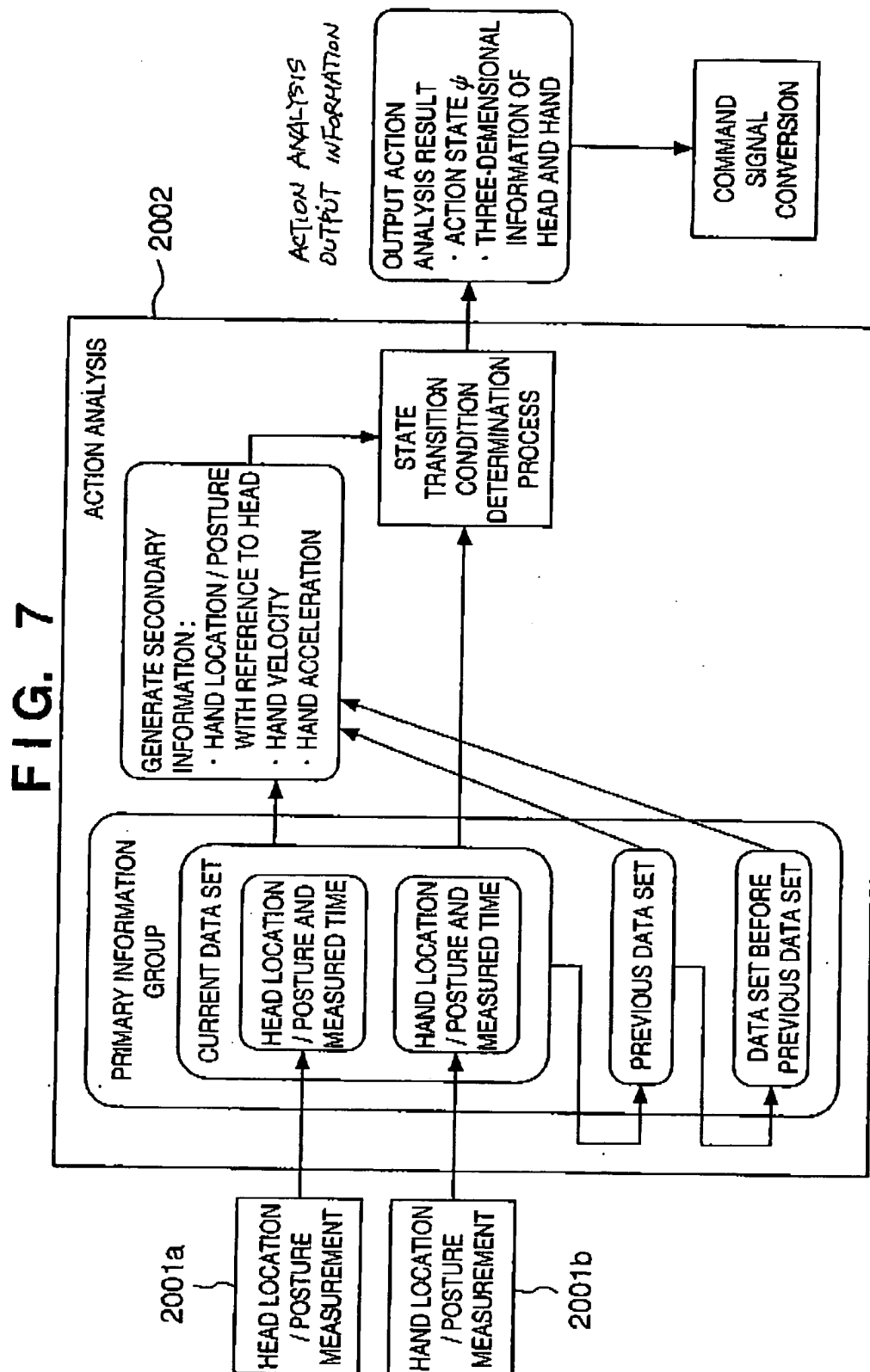
HEAD COORDINATE SYSTEM  
(VIEWED FROM TOP)  
頭部の座標系(上からの図)

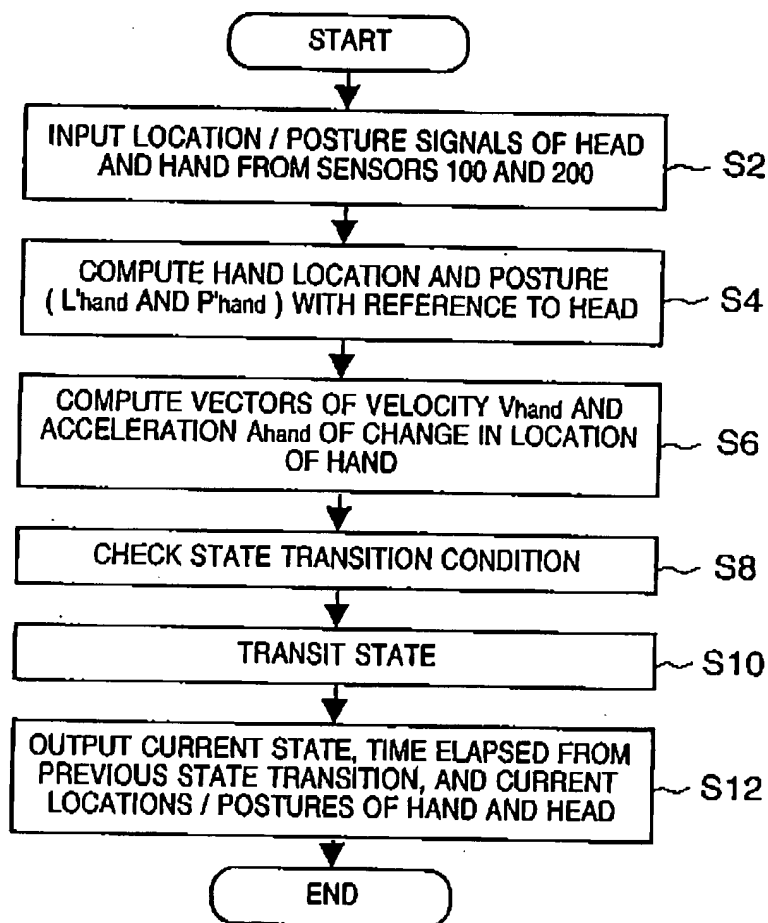


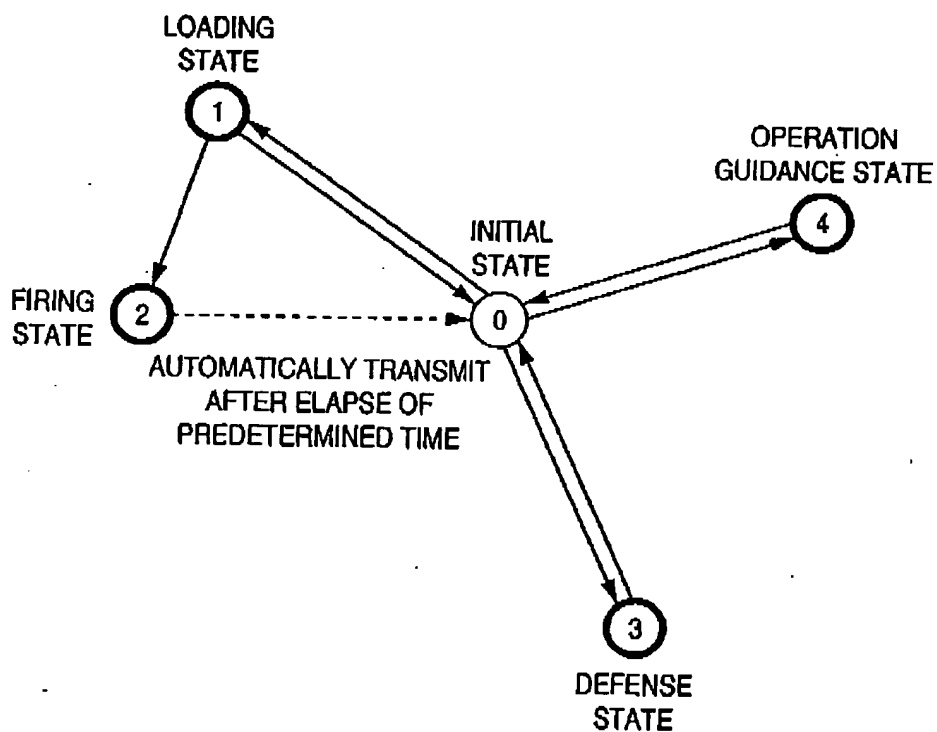
**FIG. 6**

HAND COORDINATE SYSTEM  
(VIEWED FROM BACK OF HAND)





**FIG. 8**

**FIG. 9**

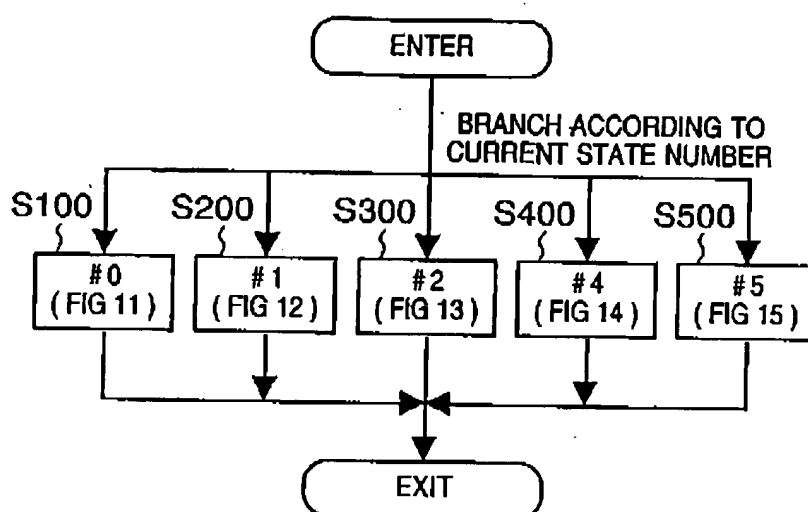
**FIG. 10**

FIG. 11

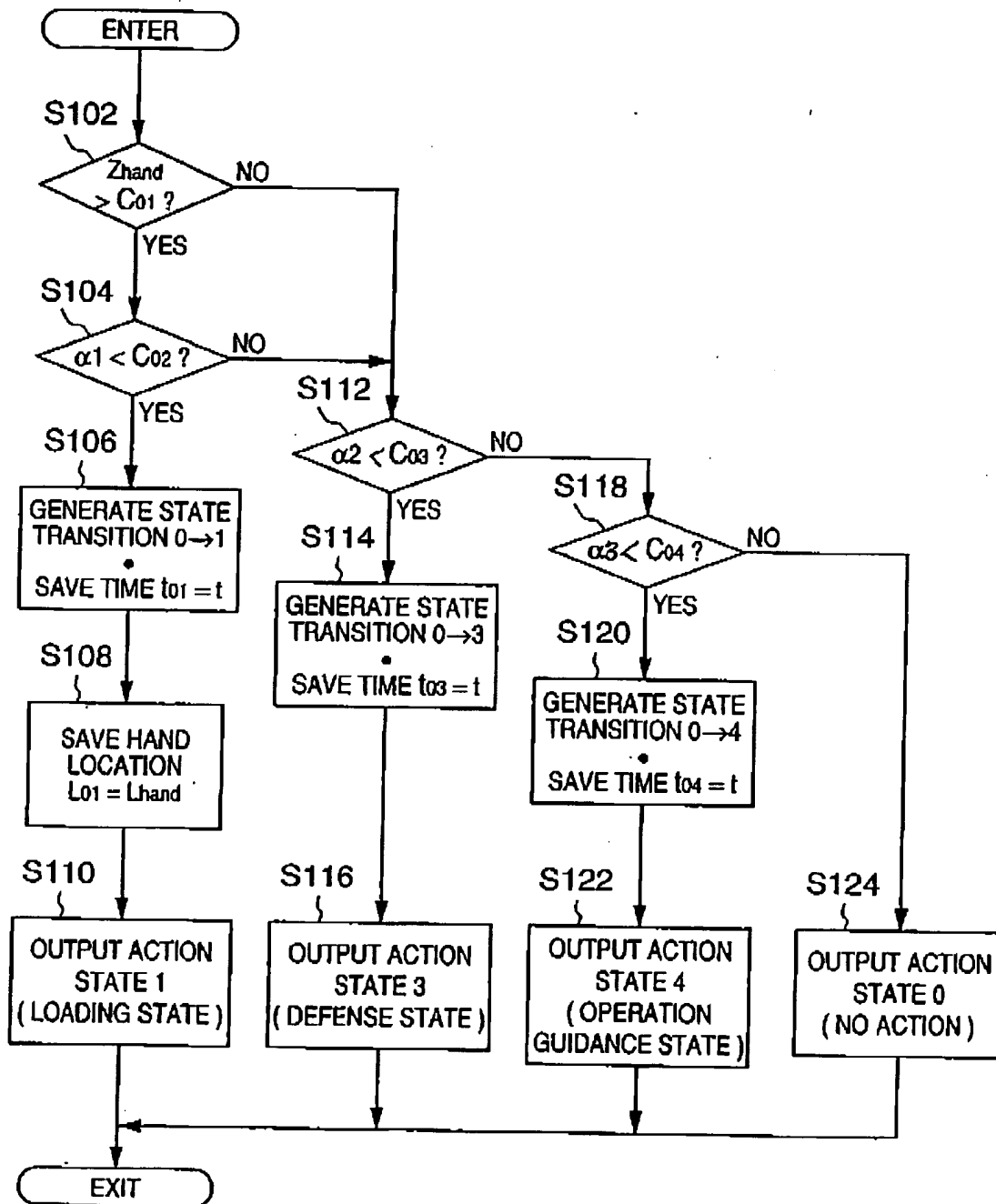


FIG. 12

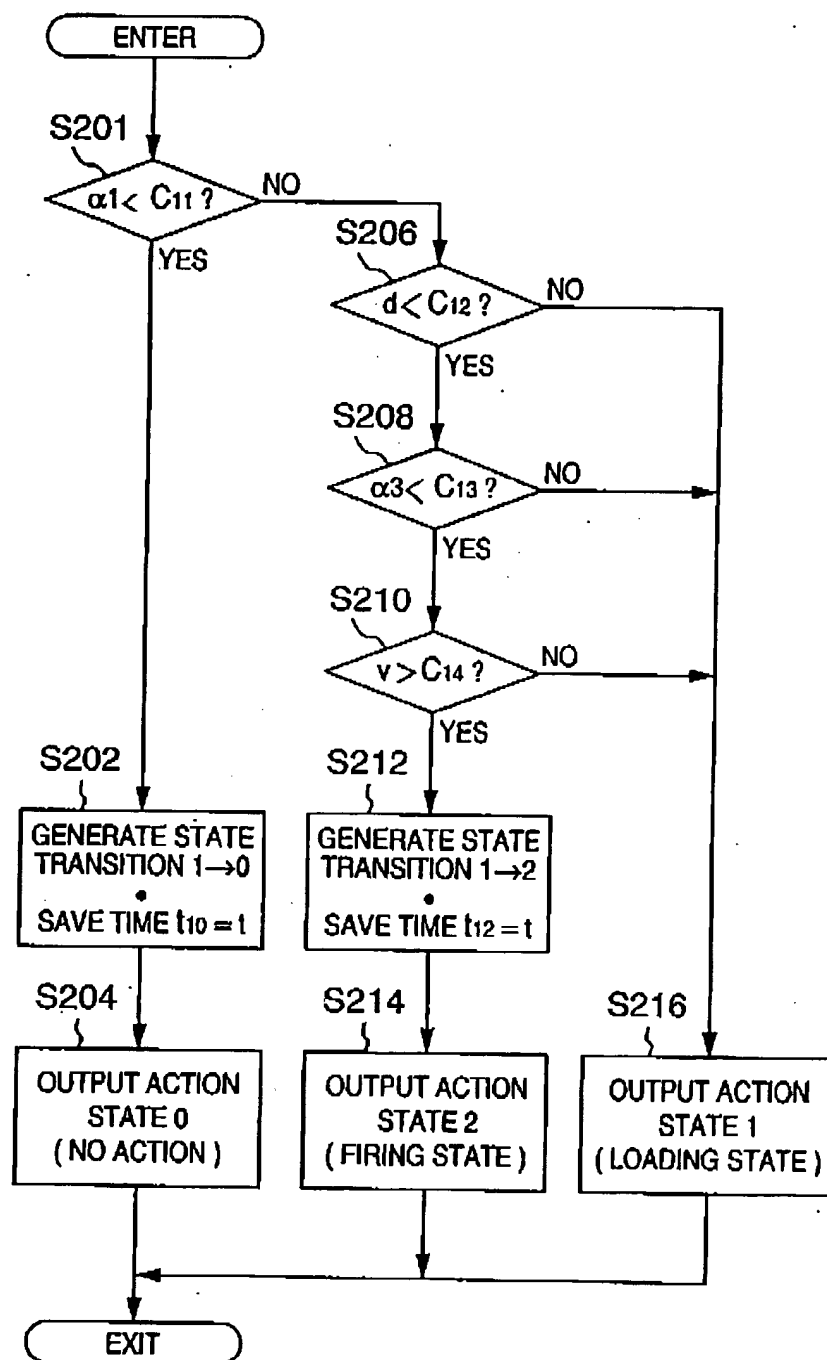


FIG. 13

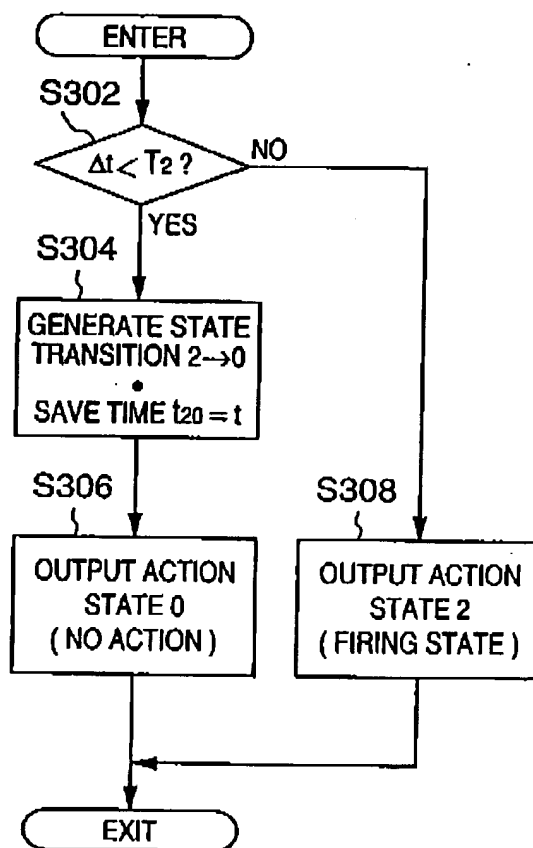


FIG. 14

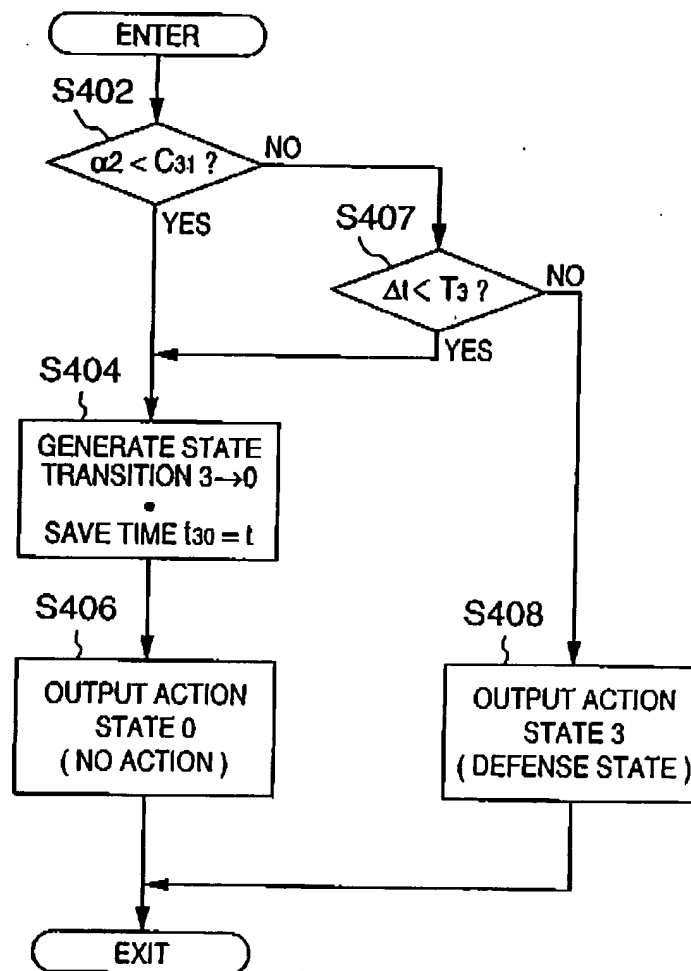


FIG. 15

